or reduced at will by blowing or suction, and it will retain its size constant when placed in open communication with the outer air by means of this tube. This is, of course, the only plane-faced polyhedron which can thus be formed, faces, edges and vertices being entirely made out of soap films. If, on the other hand, a figure has its dihedral angles greater than 120°, then the internal bubble will have concave faces, and will, if placed in communication with the outer air, increase in size until it coincides with the faces of the frame, and will then be kept in equilibrium by their rigidity. This I verified in the case of the eicosihedron.

There is one important law which must be mentioned. I found a certain irregularity in the behaviour of the films in the case of the octahedron and rhombic dodecahedron. This was due to the fact that two films cannot cross one another at right angles, a law which can be put to the test by placing two plane loops covered with film at right angles, when a small lanceolate film will be formed making two curved lines of intersection with the film on the loops, instead of allowing them to intersect in a single straight line. In the case of the rhombic dodecahedron this slightly modifies the form of the internal bubble, introducing a small edge and a little curvature at each of the acute vertices. This defect causes a serious convexity if the bubble is small, but in general we have double curvatures at the points in question, the remaining portion of each face being plain while the figure retains the form of a rhombic dodecahedron. W. F. WARTH.

Reversal of Charge from Electrical Induction Machines.

THE reversal of the poles of a Voss machine by giving some turns in the wrong direction, as observed in NATURE of January 5 (p. 221), is not an unknown phenomenon. It is described in my paper "Essai sur la Théorie des Machines électriques à influence" (Gauthier-Villars, Paris, 1898), p. 38, together with a much more trustworthy and simpler means—an improvement, in theory and in fact. This consists in discharging by hand, at the same time, both the inductors of the fixed disc. Then the reversal is invariably observed without stopping the machine.

V. SCHAFFERS.

Louvain (Belgium), 11 rue des Récollets.

THE CONSTRUCTION OF SIMPLE ELECTROSCOPES FOR EXPERIMENTS ON RADIO-ACTIVITY.

THE electrical method, where it is applicable, is now by far the most sensitive method of detecting small quantities of matter; and the recent advances in physical science made by the method of measuring small leakages of electricity, especially in connection with the phenomena of radio-activity, have excited a very general interest in the experimental arrangements employed. The writer hopes that the following account of simple electroscopes for this kind of work will be found to be of a practical nature and of service to those who, though unfamiliar with many of the devices in general use in a physical laboratory, are nevertheless desirous of making quantitative experiments on radio-activity or some other subject where the electrical method is employed.

In general the final shape of the instrument will depend very much on the purpose for which it is required; in fact, it is one great advantage of the gold-leaf electroscope that it can usually be fixed up in any odd corner of the apparatus which happens to be convenient. There is, however, one part of the apparatus which is always the same in sensitive instruments, and that is the gold-leaf system itself. Before describing this it will perhaps make things clearer if we consider for a moment one or two points about the theory of the instrument.

What we observe usually is the rate of decrease of the deflection of a charged gold leaf from a vertical metal support to which it is attached. Now the deflection in question depends only on the shape and size of the leaf and of the metal support, and on the electrostatic potential of the system, so that the rate of collapse of the leaf measures the rate of decrease of the electrostatic potential. But what we wish to measure is the current or rate of alteration of electric charge, and this is equal to the rate of decrease of potential multiplied by the electrostatic capacity of the system. Thus for a given current the rate of movement of the gold leaves is greater the smaller the capacity of the system. For a sensitive instrument it is therefore absolutely necessary to have the parts which are metallically connected with the gold leaf as small as possible.

Cutting gold leaves is a process which requires a considerable amount of patience, especially from the beginner. The process I always adopt is to take a plate of glass and lay a sheet of smooth note paper on it. On this the gold leaf is spread out flat by blowing gently if necessary, and is cut by means of a razor. To do this, all except a narrow strip at the edge is covered with a second sheet of note paper, the straight edge of which is pressed down with the fingers so as to hold the gold leaf. A fine strip outside the edge of the paper is then cut off from the leaf by dragging the razor gently backwards parallel to itself and to the edge of the paper. It is not necessary to exert any great pressure during this operation, but a little practice will be necessary to get into the way of doing the saw-cut stroke at the proper speed. Mr. C. T. R. Wilson has succeeded in this way in cutting uniform strips one-tenth of a millimetre across, but for most purposes strips one millimetre wide are good enough. In working with gold leaf much trouble will be saved by working in a room which is free from draughts and disturbances generally.

For the metal support to which the gold leaf is attached it is convenient to use a piece of wire of about the same diameter as the thickness of the gold leaf. To fix the leaf on to the wire it is sufficient just to moisten the latter at the point of attachment with the tip of the tongue; on allowing the end of the gold leaf to come in contact with the very slightly moist wire it will be found to attach itself sufficiently firmly for all that is required of it. For obvious reasons the cutting and mounting of the gold leaf should be the very last operation in the construction of the electroscope.

In constructing an electroscope it is of the utmost importance to have trustworthy insulation. When the apparatus has not to be raised to a high temperature, and great mechanical strength is not required, sulphur is a long way better than anything else for this purpose. Generally speaking, it is better to have as small a quantity of insulating material as possible in order to diminish irregularities caused by the superficial charging up of the dielectric. Suppose we wish to insulate the wire carrying the gold leaf from another wire which supports it mechanically we should proceed as follows:—Take a porcelain crucible and gently heat a quantity of pure flowers of sulphur in it until it just melts and forms a clear yellow limpid liquid. It is important that it should not be heated so strongly as to become dark coloured and viscous, as this appears to diminish its subsequent insulating properties. The end of one of the wires is then dipped into the liquid sulphur, when a coating of sulphur forms on the wire. This is allowed to cool until it has solidified, and the operation is repeated a number of times until a bead of sulphur like that shown in Fig. 1 A has formed on the end. The end of the other wire is now heated gently in the flame and applied with a slight pressure to the point *a*, when it melts its way into the sulphur;

and if the operation has been successfully carried out the result will be as indicated in Fig. 1 B.

In this sort of work it is often necessary to make sulphur stoppers, &c., of various shapes. To do this it is only necessary to make paper models of the required shape, into which the sulphur is cast. The paper generally sticks to the sulphur, but may be taken off with a clean knife without impairing the insulation. It is advisable to do this, and also any cutting away of the sulphur that may be necessary, immediately after it has set, since it becomes very hard and brittle soon afterwards.

For ordinary work with radio-active substances it is not necessary to employ the most sensitive type of electroscope, and for such work the design shown in Fig. 2 is very convenient. It consists of a brass cylinder of about the proportions shown and 10 cm. high. The top is closed by a flat plate with a narrow tubular opening *a*, into which a sulphur stopper *b*, cast as above, fits fairly tightly. The sulphur is best cast round the wire destined to carry the gold leaf. For examining the properties of various radiations the bottom may be made in the form of a ring, as shown. This is fixed by the slot and pin indicated or some

Fig 1

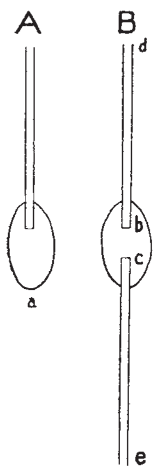
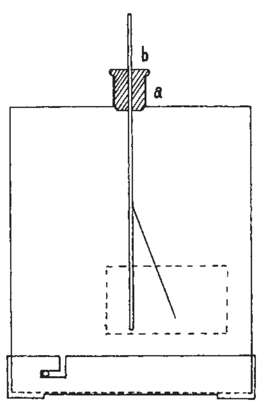


Fig 2



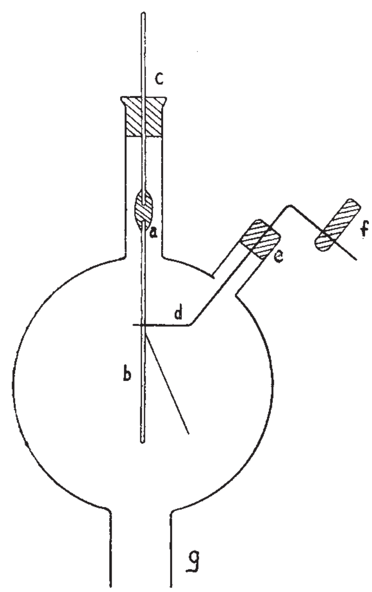
similar arrangement, and the circular hole in the base can be covered with sheets of foil, &c., if it is desired to examine the penetrating power of the rays under investigation. In all these instruments a hole has to be cut in the metal both in front and behind the gold leaf to illuminate it and to read its position. The holes are conveniently of about the relative size shown; they may be covered up with glass, mica, or transparent celluloid, whichever is most convenient. A suitable illumination is obtained by placing a sheet of white paper in front of a paraffin lamp about twelve inches behind the electroscope. The movement of the leaves is most conveniently read by means of a microscope of about 6 cm. focal length furnished with a micrometer eye-piece. It is advisable to have a microscope with as short a focal length as possible to increase the magnification, and therefore the sensitiveness.

The final appearance of the electroscope will depend very much on the appliances at the disposal of the experimenter. An instrument of this character could quite well be made out of a cigarette tin, but it would probably be more satisfactory to have the metal parts made by a competent mechanic.

If cells are not available the above instrument is readily charged by allowing a rubbed sealing wax or ebonite rod to spark to the outside wire. In measuring leaks the gold leaf should always be charged to about the same extent, as the sensitiveness depends a good deal on the amount of the deflection. The instrument will not keep its charge indefinitely, but will show a small leak even if no radio-active substances are present; this is nearly all due to the so-called spontaneous ionisation of the air. There is practically no leakage across the sulphur if the instrument is properly made.

For some purposes a more convenient arrangement is that indicated in Fig. 3, where the figure is drawn so as to exhibit the electroscope in its most sensitive form, *i.e.* with the minimum capacity. A piece about 4 cm. deep is cut off a wide brass cylinder, and the side tubes fitted on as shown. The gold leaf is carried by the wire *b*, and is insulated by the sulphur bead *a*, formed in the manner already described. Thus the insulation leak can only take place to the support *c*, and can be entirely prevented by keeping *c* at the same

Fig 3



potential as *b* by means of cells. The insulation of the wire *c* from the tube which supports it need not be of a very high order; it is sufficient to fix it in with a rubber stopper in the manner shown. So far we have all our charged system enclosed, so that there arises the difficulty of charging it. This is done by means of the wire *d*, which can be rotated about an axis through the centre of the ebonite stopper *e*. It is advisable to remove the wire *d* from the gold-leaf system when once this has been charged. By means of the sealing-wax handle *f* this may be accomplished without discharging the electroscope. The instrument is so far open. It is conveniently closed by two squares of window glass cemented on to the brass cylinder with sealing wax. The whole of the outside is then covered with thin lead sheet or tin foil to obviate effects due to the glass getting charged. Suitable windows must be cut in this to allow the position of the gold leaf to be read.

The above arrangement is as sensitive as this type of instrument can conveniently be made, since its capacity is only that of a short piece of wire and the

gold leaf. Generally speaking, the capacity in electrostatic units is found to be of the same order as the length of the wire. In this or a slightly altered form, the instrument is suitable for experiments on spontaneous ionisation and the radio-activity of ordinary materials.

In experiments on emanations, induced activity, and very penetrating rays it is often convenient to increase the magnitude of the effects by allowing them to ionise a large volume of air. For this purpose the arrangement last described is particularly convenient. It is only necessary to solder a long straight wire upon the lower end of *b* and to fix *g* by means of a rubber stopper into the neck of an oil can. The leak then measured is due to the ionisation produced throughout the volume of the can. The sensitiveness, though greater than before, is not increased in the ratio of the volumes, as would otherwise be the case, owing to the increased capacity produced by the additional wire. This arrangement is especially useful for examining the induced activity which may conveniently be deposited on the wire.

A still more sensitive type of electroscope was recently invented by Mr. C. T. R. Wilson. It does not, however, appear to be an instrument which can be safely recommended to the inexperienced, so that it scarcely comes within the scope of this article. It is described in the Cambridge Phil. Soc. *Proc.*, vol. xii. p. 135, and may be bought from the Cambridge Scientific Instrument Company. Much further information about electroscopes and electrometers for radio-active work will also be found in Prof. Rutherford's book on radio-activity, chapter iii.

O. W. RICHARDSON.

GEOLOGICAL SURVEY OF CANADA.

THE Geological Survey of Canada, which was established in 1842 under the direction of Mr. (afterwards Sir) William E. Logan, commenced its labours with 1500*l.*, which was voted by the Provincial Legislature. The sum seems to have been granted without any clear idea of the length of time which the survey would take, but apparently it was expected to last about two years.

In the winter of 1844–5 the amount was expended, and Logan was more than 800*l.* out of pocket. Eventually provision was made for the continuance of the survey for five years with an annual grant of 2000*l.* Notwithstanding many difficulties and disappointments vigorous progress was made in the field work and office work, and this has been continued for upwards of sixty years under the successive directors, Selwyn, George Dawson, until now, when the survey, under Dr. Robert Bell, is provided for better than at any previous time. Thus the total votes for the present financial year amount to 22,800*l.* for general purposes, and to about 8000*l.* for the salaries of permanent officers.

We gather from the last summary report by Dr. Bell that while the Canadian Geological Survey, like that of the United States, has been engaged in palæontological, zoological, botanical, ethnological, and archæological investigations, by far the largest proportion of the work has been of an economic and practical character. Thus the justification for the increased support given to the survey is amply supplied by the investigations which have been carried on with the view of aiding the development of the mineral resources of the country. Up to the end of 1903 the publications of the survey included about 350 maps, of which 100 relate especially to mining districts; and about 250 reports and bulletins, amongst which nearly 100 are exclusively economic. During the four years of Dr. Bell's directorship, the field parties have been increased, and during the past year they have worked in many interesting districts, from the Yukon and British Columbia in the west to New Brunswick and Nova Scotia in the east, and from southern Ontario and Quebec to Lancaster Sound in the Arctic regions. Their researches have had reference to gold, silver, lead, copper, graphite, corundum and mineral pigments; to coal, peat, petroleum and natural gas; to various building and ornamental stones, clays and cement ingredients. Hitherto unknown sections of the country have been explored and surveyed, and observations have been made on the timber, soils, and water supply, as well as on the general natural history.

The palæontological work of the survey has been carried on by the veteran palæontologist Dr. J. F. Whiteaves, aided in the department of vertebrates by Mr. Lawrence M. Lambe. In the "Contributions to Canadian Palæontology" (vol. iii.), recently issued by the survey, Mr. Lambe has described some remains of the carnivorous dinosaur *Dryptosaurus incrassatus* (Cope), from the Edmonton series of Alberta, in the North-West Territory. The strata belong to the Lower Laramie (Cretaceous) formation. The importance of a more intimate knowledge of the fauna of the Edmonton series is apparent when it is borne in mind that the beds of this series in Alberta constitute the principal coal-bearing horizon of the district.

Dr. Bell himself has been partly occupied, in conjunction with other leading geologists in Canada and the United States, in investigating the crystalline rocks in Upper Michigan, in Wisconsin and Minnesota, and in the Rainy River, Thunder Bay, and other districts of Ontario, with the view of settling disputed questions. The controversies on these rocks have long been occupying attention without any definite result. A few years ago Dr. Bell urged upon the International Committee of Geologists the desirability of forming a small central committee, the members of which should go to the ground together and look at the facts. This was carried out, and as a result the members have come to an almost complete agreement on all the vexed points. The standing committee consists of Dr. Bell and Dr. F. D. Adams (professor of geology in McGill University) for Canada, and Dr. C. W. Hayes (chief geologist of the U.S. Geological Survey) and Prof. C. R. Van Hise (president of the State University of Wisconsin) for the United States. By invitation there were also associated with them Prof. Leith (of the University of Wisconsin), Dr. Lane (State geologist of Michigan), Prof. Seaman (professor of geology in the College of Mines at Houghton, Michigan), Messrs Sebenius and Merriam (geologists of the Iron Ranges), and Prof. W. G. Miller (provincial geologist of Ontario). It is anticipated that the joint report will shortly be published.

RECENT EXPLORATION IN THE MENTONE CAVES.

PROF. MARCELLIN BOULE has recently been studying the deposits in the well known caves of the Rochers rouges (Baoussé-roussé of local patois) near Mentone, and read a paper on his results before the Société géologique de France in the early part of last year, which is published in the society's *Bulletin* (No. 1). Since the original discovery by M. Rivière of a human skeleton in one of these caves, the question of the age of their deposits has been debated with much warmth, but without any satisfactory result. In recent years the caves have been carefully and systematically explored under the direction of the Prince of Monaco, with the result that a great number of fossils have been obtained. Prof. Boule's researches were